JANUARY 28, 1985

CHEMICAL & ENGINEERING

NEWS

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Acid Rain in Europe

Tree damage sparks action

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CHEMICAL & ENGINEERING
NEWS
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News of the Week

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Student Pugwash international conference invites college students to discuss ethics, social aspects of science and technology. **Page 35**

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Cover: Damaged trees in West German forest. Photo copyright: Artreference, Frankfurt

News Focus

Reports of increasing damage to trees, lakes, and monuments lead West and East European countries to agree to lower emissions of sulfur dioxide. **Page 12**

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Chemical & Engineering News

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LETTERS

Early history about methylene

SIR: The recent article (C&EN, Nov. 26, 1984, page 30) discussing the resolution of questions concerning the properties of methylene omitted some interesting early history of work on this substance.

G. A. Gallup [*J. Chem. Phys.*, **16**, 716 (1957)] was the first to give a theoretical treatment that predicted methylene to be in a bent triplet ground state. This result ran counter to the view commonly held at the time that the Jahn-Teller effect would force methylene to be sharply bent but with a singlet ground state. The calculation used what today would be called an extended Hückel treatment with, however, some additional semiempirical information obtained from excited states of the carbon atom that is not typical of that approach.

The spectroscopy of methylene at that time was still under investigation, but the available results seemed to rule out a sharply bent structure [Herzberg, *Rev. Mod. Phys.*, **14**, 195 (1942)].

Gas-phase kinetic studies by W. A. Noyes Jr. suggested that methylene might have a ground, or very low-lying triplet state. This was reported in an ACS tour lecture given in Nebraska by Noyes, but he never felt sure enough of this conjecture to publish it. Gallup was led to his investigation by this talk.

Craig J. Eckhardt
Professor of Chemistry
University of Nebraska, Lincoln

Credit to Bassow and ACS staff

SIR: A recent article (C&EN, Dec. 24, 1984, page 32) reported an award to ACS by President Reagan's Citation Program for Private Sector Initiatives. The ACS initiative was to make technical personnel and other resources in chemically related industry available to secondary schools in the Philadelphia area. Besides Corporation Associates, several groups in the society were essential to the initiation and support of the program, particularly the board of directors and the Committee on Science. Nancy M. Flinn, staff coordinator for Corporation Associates, played a major role in the success of the effort.

Of special importance is recognition of the individual who implemented the program in Philadelphia. Herbert Bassow, an award-winning chemistry teacher from Germantown Friends School, used his sabbatical to this end. He talked with hundreds of teachers and individuals in industry to determine local high school needs and the industrial resources available to fill them. His findings were compiled as the "High School Chemistry Resource Directory for the Philadelphia/Camden Greater Metropolitan Region" and distributed to the schools in the area.

Bassow and the ACS staff are to be congratulated for the efforts which led to the award.

E. Wasserman, *Chairman*
Committee on Corporation Associates

Ads in C&EN

SIR: A full-page ad has appeared several times in the "Employment" section of C&EN, sponsored by the department of sciences at Abadan Institute of Technology in Iran.

I cannot understand why C&EN is carrying such ads. The advertiser, the Islamic Republic of Iran, is certainly no friend of the U.S. The hostage crisis several years ago is still fresh in our minds, and the Iranian government almost nightly abuses the U.S. on the news media.

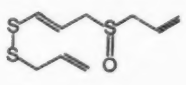
This ad should not have been accepted and those responsible for accepting it should be held accountable. The membership of our organization should not tolerate such poor judgment. Patriotism should not be utilized in political campaigns and on July 4th only; it should be held in very high regard by ACS.

Bernard M. Mitzner
New Hampton, N.Y.

Editor's Note: C&EN policy on the publication of advertisements from foreign employers was discussed at the December 1984 meeting of the C&EN Editorial Board. The consensus of this board was that publication of the advertisement from the Abadan Institute of Technology was not inappropriate and that it would not be practical to develop a blacklist of nations from which such advertisements would not be accepted.

Corrections

- Jan. 7, page 34: The structure of ajoene, as shown, has three (not two) sulfur atoms:



Ajoene

- Jan. 14, page 20: Planned 1985 R&D spending by Union Carbide is $280 million, not $275 million.
- Jan. 14, page 44: The date of the State-of-the-Art Symposium on Degradation of Materials to Acid Rain is June 17–19, 1985, not 1984.

European Concern About Acid Rain Is Growing

Motivated in part by reports of widespread and increasing tree damage, many West and East European countries now have pledged to reduce their sulfur dioxide emissions substantially by 1993

Dermot A. O'Sullivan, C&EN London

When West Germans learned a few weeks ago that half of their tree population is showing signs of damage, the news was greeted with a sense of national alarm. Germans have a close and almost spiritual relationship with their forests, which have inspired music and folklore. So the idea of such a large number of trees being under stress is almost inconceivable. Blame for damage is attributed to acid rain.

The data issued by the federal Ministry of Food, Agriculture & Forestry in Bonn appear the more ominous because in 1983, 34% of the country's forested area was identified as being damaged. The previous year, the level was put at a mere 8%.

Admittedly, the sharp rise hasn't occurred in the short span of three years. Rather, it reflects a better and more widespread system of identification. Neither does it mean that all the trees exhibiting signs of damage are on the verge of death. Trees in less than 3% of the forested area are classed as being "severely sick." But the findings do indicate that something is seriously wrong.

Species showing the most damage are conifers such as fir, pine, and spruce. However, deciduous trees like beech also are affected. One of the most damaged areas is the famed Black Forest, which is largely covered with conifers.

Germans call the tree problem "neuartige waldschäden"—literally, "new kind of forest damage." It is characterized by a yellowing of the needle tips, premature defoliation, and dieback. Because this occurs high up

Severe forest damage in the Erz Gebirge region of western Czechoslovakia from air pollutants from heavy industry

Many Norwegian lakes are picturesque but "dead" because of their high acid content

in the crowns of the trees, few people who stroll through the woods are aware of the damage, comments Manfred Häberle, who is in charge of emissions control and ecology at BASF and also chairs the working party for forest damage at West Germany's Chemical Industry Association. BASF, one of West Germany's big three chemical concerns, is engaged in an ongoing forest research program funded partly by the West German government.

Häberle subscribes to one of several major theories about how air pollutants damage trees. Like a number of other explanations, the theory involves a combination of factors. One of these is the weather. Heavy rains in spring and fall, coupled with incidents of summer drought or unusually high temperatures, adversely affect tree growth, as evidenced by the pattern of tree rings.

In such a weakened state, the reasoning goes, trees are more susceptible to the leaching out of calcium, magnesium, and other essential nutrients from the soil, which, in turn, is promoted by acidification from acid rain. The effect is more pronounced at higher altitudes where the soil tends to be thin. Häberle makes the point that, in relative terms, a pine tree requires the same amount of calcium and magnesium as wheat does for proper growth. He notes that in young trees, yellowing of the needle tips is reversed by applying calcium and magnesium compounds at their base.

About the time West Germany issued its findings, Sweden's Ministry of Agriculture provided its own set of data on the state of tree damage in the southwestern area of that country. There, too, stress on the conifers appears on the increase. And there, too, acid rain in conjunction with ozone is being named as the culprit.

The two reports, coming so close together, have added to the groundswell of concern throughout Europe on the deleterious effects of acidic components in the atmosphere. And the damage is not limited to trees.

Many historic buildings throughout Europe are bearing the brunt of the attack. An official at Cologne's famed cathedral deplores the fact that by replacing damaged stone, he is overseeing the replacement of a medieval monument.

A report issued last fall by the U.K.'s Parliamentary Environment Committee cites evidence taken from people responsible for the upkeep of St. Paul's Cathedral, Westminster Abbey, and similar structures throughout the U.K. The study quotes architects associated with Lincoln Cathedral, for instance, as saying that the recent acceleration in the deterioration of stonework, particularly that of Romanesque and medieval statuary, is caused by acid rain.

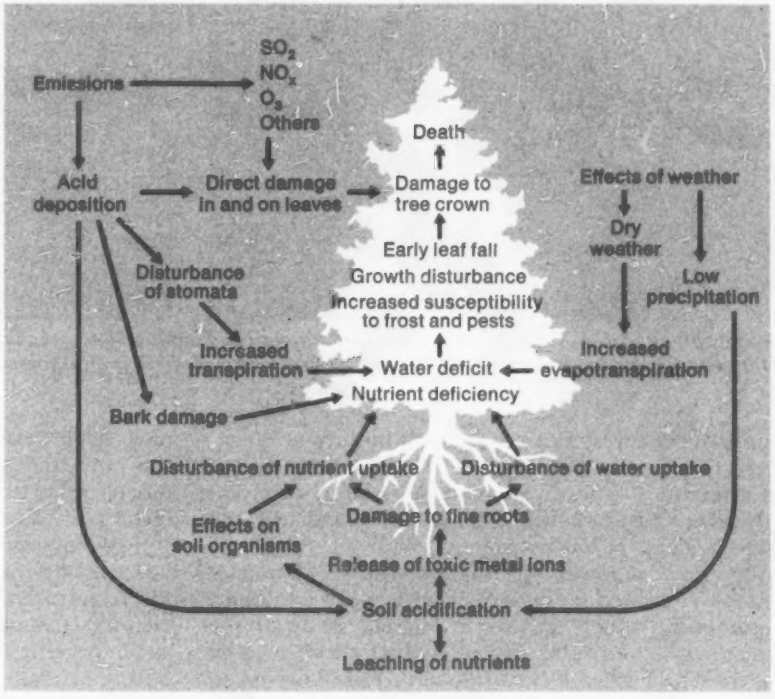
"It is beyond doubt," the report notes, "that acid rain, mainly due to sulfur dioxide emissions, is damaging British buildings, and slowly but surely dissolving away our historic heritage." It recommends that the British government "give urgent and immediate consideration to the cost benefit of preventing the avoidable erosion of both historic and modern buildings."

The acid rain issue is at once simple and extremely complex. Its simplicity rests on the nature of the chemicals involved, essentially sulfur dioxide and sulfates, nitrogen oxides (generally referred to as NO_x), and ozone produced in the atmosphere from nitrogen oxides and hydrocarbons under the influence of ultraviolet light.

That atmospheric acidity adversely affects a variety of ecosystems—from forests in central Europe and Scandinavia to lakes in Scandinavia and Scotland—can hardly be refuted. But the complexity of the subject is reflected in the many theories, some of them conflicting, that have been proposed to explain its mode of action.

Apart from circumstantial evidence, no one really knows precisely the chemical and physiological pathways involved. However, much more is known about the acidification of lakes from acid deposition than is

Air pollutants may damage trees in many ways



Source: Swedish University of Agricultural Sciences

Dean and Chapter of Lincoln

Photograph of grotesque decorating Lincoln Cathedral in England (left) was taken about 1910, whereas photograph of the same grotesque, taken in 1984, shows effects of atmospheric pollutants on the stonework

known about forest damage from air pollution. Meanwhile, the issue has been pushed into the forefront of the international political arena, spurred by economic, health, and aesthetic considerations, and to some extent by emotive journalism.

The term "acid rain" itself is something of a misnomer. It was coined more than a century ago by Robert Angus Smith when making a detailed study of the atmospheric conditions in the industrialized area of Manchester, England, and the term has since taken hold.

Acid deposition is the more accurate and scientifically preferred term. It is true that sulfur dioxide undergoes oxidation to the trioxide, which in turn converts to sulfuric acid in clouds, fogs, and mists. On the other hand, dry deposition of acidic aerosols and particulates is deemed to be just as damaging, especially as far as the adverse effects on trees and historic buildings are concerned. Moreover, ozone and heavy metals, which contribute to ecosystem damage, are not themselves acidic.

Increase in the level of man-made air pollutants over Europe, and the concomitant rise in the intensity of acid deposition, can be traced back to the industrial revolution. As recently as 30 years or so ago, air quality over heavily industrialized centers had deteriorated to the point where women's hose were known to disintegrate during rainy spells because the level of acidity was high enough to attack the man-made fibers.

Widespread burning of coal both for power generation and domestic heating also led to development of severe episodes of smoke haze combined with weather-related fog. London's "pea-soupers" are legendary. In 1952, some 4000 died, due largely to inhalation of smoke particles on which sulfur dioxide was absorbed. A similar incident there in 1962 brought death to about 800. So bad were conditions that an internationally acclaimed collection of pine trees at the Botanical Gardens of Kew had to be moved out of London to ensure their survival.

Great strides have been made to overcome such problems. Many West European countries now have laws regulating the type of fuels that may be burned to reduce smoke output. Also, ever taller smokestacks have been built. Although this helped conditions in the immediate neighborhood of emission sources, it did nothing to improve the environment of regions farther afield.

Sweden's system of atmospheric monitoring stations, set up in 1952, eventually was extended to most of Western Europe, including the U.K. These stations began accumulating evidence of increasing sulfate and inorganic nitrogen compounds in rainwater, and falling pH values of the rain.

By 1968, sufficient information had been accumulated to allow Svante Odén, professor of soil science at the Swedish University of Agricultural Sciences in Uppsala, to make a detailed analysis of the data. Odén, who is credited with being the one to initiate the warning signals of the spread of acid rain, showed that a central area in Europe with precipitation more acidic, and containing higher amounts of sulfate and inorganic nitrogen than surrounding areas, had been expanding from year to year.

He clearly demonstrated the long-range transport to Scandinavia of sulfur dioxide and inorganic nitrogen compounds from the U.K. and from Central and Eastern Europe. He also established a link between this and the increasing acidification of lakes and rivers throughout Scandinavia where falling fish populations were being reported.

Odén, who warned of the likelihood of what he calls a chemical desert developing globally north of the 45th parallel unless air pollution is abated, joined with his Swedish colleagues in providing a detailed report on acidification and its consequences to the United Nations Conference on the Human Environment held in Stockholm in 1972. Influenced by this report, the Organization for Economic Cooperation & Development in Paris that same year launched what came to be known as LRTAP, the Cooperative Technical Program to Measure the Long-Range Transport of Air Pollutants.

LRTAP set out to determine "the relative importance of local and distant sources of sulfur compounds in terms of their contribution to air pollution over a region, special attention being paid to the question of acidity in atmospheric precipitation." Eleven West Eu-

ropean OECD member countries participated, with the Norwegian Institute for Air Research acting as the central coordinating unit.

It became evident, however, that the question of transboundary air pollution in Europe needed to be studied in a wider context, and that the East European countries, which aren't OECD members, should be brought into the discussions. So it was that the focus of activity shifted to the United Nations Economic Commission for Europe (ECE) in Geneva to which East-bloc countries belong.

In November 1979, 34 countries and the European Economic Community signed a convention on long-range transboundary air pollution, undertaking to "limit and, as far as possible, gradually reduce and prevent air pollution, including long-range transboundary air pollution." This convention became effective in March 1983, when it had been ratified by a sufficient number of signatories extending from Canada and the U.S. to the Soviet Union.

Prior to this convention, ECE also had set up a European Monitoring & Evaluation Program. Known as EMEP for short, sulfur deposition readings are made daily by national monitoring stations throughout East and West Europe using standardized equipment and techniques. The Chemical Coordinating Centre near Oslo collates the information and provides quality control of the data. Meanwhile the Meteorological Institute in Oslo and the Geophysical Institute in Moscow collaborate with one another on the verification of meteorological models with backup from the UN's World Meteorological Organization.

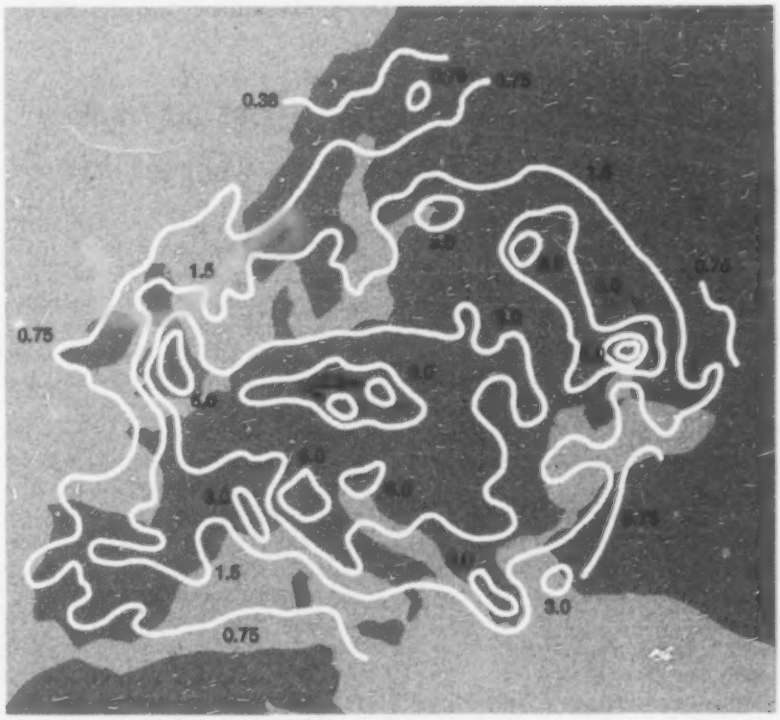
To date, measurements have centered mainly on sulfur dioxide and sulfates, along with pH values. There are two reasons for this. They were viewed as the principal actors early in the acid rain debate. Besides, methods for their measurement were well developed and fairly easy to carry out. Plans are under way to extend the readings to include nitrogen dioxide, ozone, particulates, and water conductivity, as well as anions (nitrate and chloride) and cations (ammonium, calcium, magnesium, potassium, and sodium).

The present state of alarm about forest damage is focusing attention on the need for ozone measurements, comments Arne Tolan, a Norwegian hydrologist who heads ECE's air pollution unit in Geneva. "Few European stations can produce ozone concentration data right now because the equipment is expensive," he explains. The main cost of the European monitoring program is paid by the national governments involved, he adds. In addition, there is a trust fund to support activities at the coordinating centers. The UN Environment Program contributes to the work.

A concept developing from this trans-European monitoring program is what people have come to call sulfur budgets. All countries generate sulfur dioxide from power stations, industries, and domestic sources, but some "export" more than they receive because of prevailing wind patterns. The reverse also is true, of course. A country's sulfur budget refers to the total annual sulfur deposition, both wet and dry, arising from its own and outside sources.

EMEP measurements show, for instance, that in 1983 the U.K. had an average monthly sulfur deposition of 847,000 metric tons, only 20% of which came from sources outside the country. In the case of Norway, on the other hand, the direction of the prevailing winds resulted in 92% of its 255,000-metric-ton average monthly sulfur deposition that year coming from elsewhere, mainly from the U.K. and from Central Europe. In West Germany, about half of the monthly sulfur deposition is emitted from within the country and half arrives from elsewhere, although the burden of "im-

Greatest concentration of sulfur deposition centers in Poland and Czechoslovakia



Note: Calculated total deposition of sulfur dioxide and sulfate ion from all emissions including background wet deposition for period October 1978 to September 1980. Units are grams sulfur per square meter per year.
Source: United Nations Economic Commission for Europe, European Monitoring & Evaluation Program

C&EN staff photos

Häberle (left): few people who stroll through woods are aware of damage. Odén (center): chemical desert could develop north of 45th parallel unless air pollution is abated. Overrein: acidification is a trans-world problem

ports" is much higher in the three regions of the country where forest damage has been noted.

When Lars N. Overrein, who heads the Norwegian Institute for Water Research in Oslo, speaks of long-range transport of air pollutants, he does so in global terms. "Acidification is a trans-world problem," he says. "Air streams traveling eastward over Scandinavia and further afield can carry oxides of nitrogen and sulfur along with other contaminants from the industrial centers of eastern Canada and the U.S.," he notes. "The sources and environmental consequences of acid deposition often are separated by thousands of miles."

Strong acids have decreased the mean annual pH of precipitation in much of northwestern Europe and large areas of North America to between 4 and 4.5, he points out. The impact of such acidity on aquatic systems in the more susceptible areas of Europe and North America are clearly documented, he adds.

Acid rain legislation possible in U.S. in 1985, but not likely

Like garden variety perennials, acid rain bills keep popping up and dying off each Congress. The 99th Congress probably will not stand out as the exception.

On the day the new Congress convened, Jan. 3, Sen. Robert T. Stafford (R.-Vt.) introduced the "Acid Rain Control Act of 1985" (S. 52). If it brings on déjà vu, it should. Stafford reintroduced the bill the Senate Environment & Public Works Committee approved last year.

Now—as then—the bill calls for a 10 million ton reduction in sulfur dioxide emissions in the 31 states east of the Mississippi River. The reduction is to take place over a 10-year period and is to be calculated from 1980 sulfur dioxide emission levels.

The Senate bill doesn't address the contribution that nitrogen oxides make to acid deposition. A committee staffer says that's because it's easier to administer sulfur controls than nitrogen controls.

Probably because last year's version of this bill was overwhelmingly approved by the Environment Committee, Stafford chose not to reintroduce his own acid rain bill. Last Congress the Senator offered a bill that would have reduced sulfur dioxide emissions 12 million tons.

He may later introduce an acid rain abatement bill more stringent than the current bill. More likely, though, he may offer a bill that takes a different approach to control. He is now exploring alternatives to the tonnage reduction scheme found in all bills introduced to date. Perhaps, he says, it may be better "to mandate an emission limit, say, of 0.60 lb per million Btu." In addition to studying the best way to control the problem, "we must ask ourselves whether the proper solution to the acid rain problem is not to demand the achievement of a target, but to demand best efforts," Stafford insists.

Although members of the House Energy & Commerce's Subcommittee on Health & the Environment have not yet ruminated publicly on optional control schemes, they are giving thought to a major emissions reduction program. It would be even more encompassing than the so-called Waxman/Sikorski/Gregg (H.R. 3400) acid rain control program that nearly was approved by the subcommittee last year.

No House acid rain bill has yet been dropped into the legislative hopper. A health and environment subcommittee staffer says Rep. Henry A. Waxman (D.-Calif.), who chairs the panel, is "waiting to see what the subcommittee is going to look like before he reaches a decision on whether to reintroduce H.R. 3400, or an entirely new bill."

That staffer suspects that Waxman

Overrein can speak with considerable authority on the subject. Before taking over his present position, he headed a Norwegian government-sponsored, eight-year joint research project titled "Acid Precipitation—Effects on Forest and Fish" that ended in 1980 (C&EN, June 14, 1976, page 14). Known as the SNSF project, short for the lengthy Norwegian title, one of the conclusions reached is that "there seems no reason to doubt that the change in the composition of the precipitation has played an important role in the acidification of fresh water."

Outcries from Norway and Sweden about falling pH readings in lakes and water catchments, and associated fish kills, didn't cause too much of a stir throughout the rest of Europe at the time. Indeed, many countries cold-shouldered the Scandinavians' calls for a limitation on sulfur dioxide emissions. Now, the recent evidence of tree damage and the belief that this is connected with increased acid deposition have made the Germans sit up and take notice. The Austrians, French, and Swiss, likewise, are voicing alarm over spreading damage in their forested areas. So it is that the governments of those countries have become ardent proponents of the so-called 30% Club.

The "club" takes its name from its aim, namely, that member countries commit themselves to cut annual sulfur emissions 30% from their 1980 base emission levels by 1993 at the latest. Proposed in 1983 by Finland, Norway, and Sweden, it got wide support at a ministerial conference in Ottawa last March. The first countries to join were Austria, Canada, Denmark, Finland, France, West Germany, the Netherlands, Norway, Sweden, and Switzerland. These have since been joined by Belgium, Belorussia (a part of the U.S.S.R.), Bulgaria, Czechoslovakia, East Germany, Italy, Liechtenstein, Luxembourg, the Ukraine, and the U.S.S.R.

Progress is well under way toward drawing up a protocol. The hope is that a text will be agreed upon at the working party's third meeting next month. If it is, it will go to the executive body's meeting in July. Assuming it passes that hurdle, the protocol will be sent to the the national governments for ratification, at which point it will become a binding legal agreement.

Although there is overall consensus on the ideal of the 30% reduction, there are two broad differences of opinion as to how it should be viewed. Western, or noncommunist, countries want 30% sulfur dioxide reduction imposed on the emission sources. East-bloc countries, on the other hand, talk in terms of a 30% reduction of transboundary fluxes. Nevertheless, that there is a general meeting of the minds on the need to move toward lowering atmospheric sulfur dioxide is, in itself, a very positive step.

Doubtless West Germany is pleased that neighboring Czechoslovakia is in the club. That country is one of the black spots in the European sulfur deposition picture. (Southern Poland and northern Spain are the others.) Gaseous emissions from the concentration of heavy industries in the western region of Czechoslovakia have wrought havoc on trees in the area, which is not far from the Black Forest across the West German border.

Conspicuous by their absence from the 30% Club

and other committee members will offer a bill that mandates over a 10-year period at least a 10 million ton reduction in sulfur dioxide emissions and more than the 4 million ton reduction in nitrogen oxide emissions required in H.R. 3400. As he explains, the old bill called for stricter standards for nitrogen oxide emissions from new power plants and from new light- and heavy-duty trucks. This year, he says, the committee is going to look into nitrogen oxide emissions from off-the-road vehicles, and these emissions also may be enfolded into a control bill. Nitrogen oxide emissions from construction equipment, trains, and other off-the-road vehicles now account for 30% of the oxide levels in urban areas, the Environmental Protection Agency says. By 1995, the agency expects that figure to climb to 35%.

The staffer on the Senate Environment Committee acknowledges that there is increasing evidence for the role nitrogen oxides play in damages associated with acid rain. And this accumulating evidence could warrant increasing controls on such emissions from mobile as well as stationary sources. Japanese studies, for example, have suggested a link between nitrogen oxide levels and adverse health effects. There is also evidence building for the role of oxides of nitrogen as well as of sulfur in forest damage, especially in the southeastern U.S.

Concern by Congressional members from upstate New York and the New England states is likely to remain the major pressure point for enacting acid rain legislation. But a staffer on the House Subcommittee on Health & the Environment believes that a factor of increasing importance in the debate will be the growing concern by influential members in the South over the economic consequences of forestry damage.

The question, of course, is whether all this concern can congeal into a force powerful enough to enact acid rain legislation. A House subcommittee staffer says, "If we can get a bill out of committee, it will be approved on the House floor. But without knowing who will be on the committee, it is hard to predict" what will happen at committee level. A Senate Environment Committee staffer says the problem in that body is "not getting a bill out of committee but having the leadership give us enough time to break a filibuster on the floor. If we're given enough time, we can probably get 65 to 70 votes."

The summary assessment for enactment of an acid rain control law: unlikely but not impossible.

The sticking point is, as always, economics. When Congress can figure out how to spread the pain equitably—as understood by the Midwest, the chief source of acid rain precursors—and when the White House supports acid rain curbs, then controls will be enacted.

Lois Ember, Washington

Most European countries import more sulfur pollutants than they produce

Belgium 161 Average monthly deposition of sulfur, hundreds of metric tons.

50 Percentage of deposition received from other countries.

Source: United Nations Economic Commission for Europe, European Monitoring & Evaluation Program

are the U.K. and the U.S. The U.K. is one of Western Europe's major sulfur dioxide producers and something of a thorn in the side of its neighbors, particularly Scandinavia, which claims to receive a large portion of U.K. emissions. Most of the sulfur dioxide comes from power stations operated by the U.K.'s Central Electricity Generating Board. The board's management argues with some justification that, compared with the other West European countries, the 30% cut in emissions based on 1980 levels would entail a disproportionate amount of expense. The U.K. already has brought down sulfur dioxide emissions from domestic and industrial sources some 40% during the past 10 years.

For the same reason, the U.K. is not pleased with a proposal drawn up by the Commission of the European Communities in Brussels that calls for a 60% reduction of sulfur dioxide emissions, and 40% each of nitrogen oxides and dust by 1995, from the corresponding annual mean levels recorded in 1980. The directive applies to combustion plants in the 10 member countries of the European Economic Community with a rated thermal output of 40 MW or more, regardless of the type of fuel used.

The cost to the U.K. power board and ultimately to the U.K. electricity consumer would be considerable if the directive were to become law. By the board's estimates, investment in the necessary hardware would amount to almost $2 billion. Amortization and operating costs would come to about $400 million a year. Against figures such as these, it probably came as no surprise that the U.K.'s ruling Conservative government earlier this month turned down a recommendation calling for a 60% cut in sulfur dioxide by 1995 made by the Parliamentary Environment Committee when its report was debated.

The power board, although objecting to undertaking such a large-scale expenditure, prides itself in funding one of Europe's largest research establishments dedicated to the environment. Moreover, Peter F. Chester, director of the company's technical planning and research division, argues that firm proof is lacking that sulfur dioxide is the prime factor in forest decline, and that it would be imprudent to invest so heavily in control equipment to meet the proposed emission standards until such proof is in.

Many among the scientific community and the public at large take issue with his view. It is a fact, however, that some researchers point to nitrogen oxides, hydrocarbons, and ozone as being more critical factors, in which case automobile exhaust gases should be kept in check.

Moves already are being made in EEC to do just that. Lead additives are being phased out of gasoline to allow catalytic convertors to be used. By October 1995, exhaust emission standards matching those currently in force in the U.S. will go into effect.

In this connection, West Germany has stolen the march on its EEC partners. Last year it decided to make catalytic convertors compulsory by 1989.

Sweden's Svante Odén is still acutely concerned that acid deposition will inevitably cause the continuing decline of ecosystems unless widespread moves are made to reverse the trend. He privately harbors the view that taxation could be roped in as an ally. He suggests that a levy of 5% or so could be imposed on all fossil fuels. The income would go to an international fund for distribution to help pay for development of the necessary emission control technology and distribution of the know-how worldwide. Indeed, such a concept might usefully be incorporated in the ECE convention. □

Chemical Stocks Performed Poorly in 1984

Confidence in chemical company earnings eroded as 1984 progressed, driving their stock prices down faster than others

William J. Storck, C&EN New York

Last year chemical stocks were not a very good investment. Although they performed well in the first half of the year, the seeming moderation in economic growth and thus in the stocks' earnings outlook in the second half of 1984 drove them well below their level at the end of 1983.

Specifically, C&EN's chemical stock index declined 20% by the last Friday of the year, compared to the final Friday in 1983, and the stock prices for 30 chemical companies followed by C&EN fell an unweighted average of 8%.

The reasons for the stock price declines are many, but since prices are generally based on forecast earnings, the reasons are practically the same as those that have slowed earnings growth in the second half of the year. Chief among these are lack of price growth and dismal foreign trade brought on by the high value of the dollar against foreign currencies.

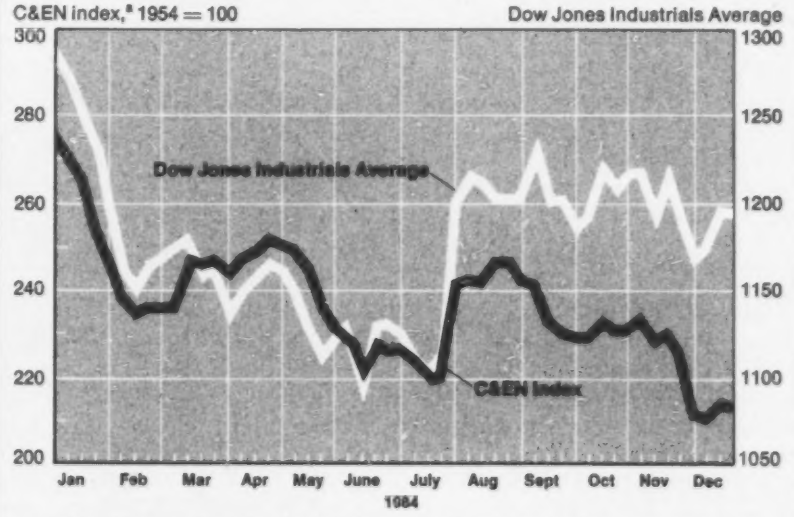
Producers have long been complaining that chemical pricing is going nowhere. Price inflation for chemicals in the past two years generally has been below that of the total economy and, although it makes little difference in the long run, their prices have been held down by falling commodity costs. For instance, even though natural gas is the largest petrochemical feedstock in the U.S., producers of petrochemicals say that their customers balk at price increases because of falling oil prices, confusing oil with natural gas as the primary feedstock. It is more of a psychological rather than real factor in pricing, they say. Then too, attempted price increases have not been helped by the continuing large overcapacity for many chemicals.

One of the main reasons for current excess capacity is the foreign trade situation. Normal overseas outlets are being shut off from U.S. producers because the high value of the dollar is pricing U.S. products out of the international market. That market traditionally has been the safety valve for U.S. chemical products when U.S. demand is not enough to soak up production. Since this safety valve no longer exists, producers cannot run plants at the speed at which they historically had been able during previ-

All major indexes outperformed chemicals last year

	Dec. 28, 1984	Dec. 30, 1983	% change
Dow Jones Industrials Average	1204.17	1258.64	−4.3%
New York State Exchange Composite	95.89	95.18	0.7
New York State Exchange Industrials	110.14	111.35	−1.1
American Stock Exchange Index	202.79	223.01	−9.1
Over-the-Counter Composite	249.08	278.60	−11.7
Over-the-Counter Industrials	256.94	323.68	−20.0
Standard & Poor's 500	166.26	164.93	0.8
Standard & Poor's 400 Industrials	185.49	186.24	−0.4
C&EN Chemical Stock Index	214	269	−20.4

Chemical stocks lost more ground than industrials in 1984



a C&EN index based on stock prices for Allied Corp., American Cyanamid, Celanese, Dow Chemical, W. R. Grace, Monsanto, and Union Carbide.

Biotechnology-related stocks fared dismally in 1984

One small investor, having taken a several-thousand-dollar flier on a newly hatched biotechnology company in early 1983, has glumly watched the value of his shares plummet to less than half of what he paid for them. As an executive of a major pharmaceutical company and holder of a doctorate in microbiology, he says he still believes in the promise of the biotechnology company's developmental products. He admits, nevertheless, to being a little nervous about his investment.

He is unlikely to be alone in that feeling. Biotechnology stock prices fell like Icarus last year. Excepting a flutter of life during the stock market's short-lived August rally, they dropped more or less steadily from the year's high point, reached in late January. When the exchanges closed on Dec. 28, the average weighted price of a universe of a dozen such stocks was a third lower than it had been at the beginning of the year.

There were exceptions to the general fall from grace, of course. The value of shares of Applied Biosystems rose dramatically over the course of the year, attaining a record high of $31½ in late November before falling back to $29 per share at the close of the year. But Applied Biosystems' products are mainly instruments and other supplies sold to biotechnology researchers. Among the more-or-less "pure play" biotechnology firms—those either manipulating genes or manufacturing products based on monoclonal antibodies—Genentech's stock was the most successful. That is to say, the price per share fell only 2% over the course of 1984. And shares of Hybritech, after touching bottom at $11 a share in July, rebounded strongly to finish the year at $16.

On the whole, though, it was a dismal year for biotechnology-related stocks. Partly, such stocks suffered from the investment community's general turn away from high-technology and medical growth stocks last year. Even more, say analysts, investors became exasperated as they realized that substantial earnings were probably further in the future than they had anticipated. As a result, even when companies were meeting business plan targets more or less on schedule, interest in their stocks waned.

"The projects may be going according to plan," says Parag Saxena, biotechnology and medical technology analyst at Citibank, "but are they being converted to products yet? No. People realized that will be slower than expected."

Another analyst, Sarah Kendell Bayles of Dean Witter, points out: "Visibility may have improved as far as projects go, but earnings visibility didn't improve."

The decline brought many stock prices to all-time company lows in 1984. Among such unwanted records, Amgen shares sank to $3¾ in late November; Biogen shares touched bottom at $4¼ in early December; Centocor hit $8 in December; Cetus sank to $8⅝ in December; Damon Biotech sank to $4½ in December; Genetic Systems hit a low of $4½; Genex sank to $4¾ in December; Hybritech, as mentioned above, fell to $11 in July; Molecular Genetics fell to $6 in late November; and Monoclonal Antibodies sank to $8.

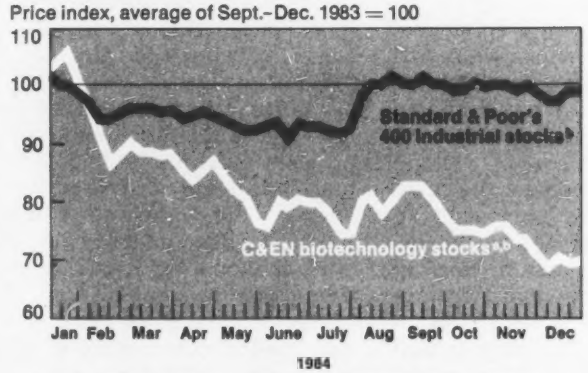
The question now is how these stocks will fare in 1985. They'll do better, if early indications have any predictive value. The price of many biotechnology-related stocks moved up smartly over the first two weeks of the new year. Genentech is a particularly notable example of this. After closing at $33¾ on Dec. 28, the price of a share had risen to $40½ Jan. 16.

Other firms whose stock prices rallied noticeably during the first two weeks of the year (as of Jan. 16 closing) are: Biogen, to $7¾; California Biotech, to $6½; Centocor, to $11; Cetus, to $10; Collaborative Research, to $5⅛; and Hybritech, to $19¾.

"This year we will see some sorting out of companies for better and worse," says Citibank's Saxena, "that will distinguish those companies that have projects that are far out from those with projects that are near."

David Webber, New York

Biotechnology stocks performed worse than rest of stock market . . .



a Based on stock prices for Amgen, Applied Biosystems, Biogen, Centocor, Cetus, Damon Biotech, Genentech, Genetic Systems, Genex, Hybritech, Molecular Genetics, and Monoclonal Antibodies. b Reindexed to average for Sept.-Dec. 1983 period to show relative change. Prices as of Friday close each week.

. . . and prices fell an average of nearly a third in 1984

Company	Year-end price[a]	Change[b]	52-week range High	52-week range Low
Amgen	$ 4¾	−34%	$ 8¼	$ 3¾
Applied Biosystems	29	61	31½	16½
Biogen	5½	−49	14	4¼
Bio-Response	4	−42	14⅜	3⅝
California Biotech	5½	−54	13¾	4¼
Centocor	8¾	−33	16¼	8
Cetus	9	−17	14	8⅝
Collaborative Research	4⅜	−35	10⅜	3⅝
Damon Biotech	4⅝	−42	10½	4½
Genentech	33¾	−2	42¼	28¾
Genetic Systems	5⅜	−39	10¾	4½
Genex	5⅜	−59	17¼	4¾
Hybritech	16	−15	23	11
Molecular Genetics	7½	−38	16¼	6
Monoclonal Antibodies	9	−25	15½	8

a As of Friday, Dec. 28, close. b Dec. 30, 1983, to Dec. 28, 1984.

Stock prices fell for most chemical companies in 1984

	Yearly close	12-month High	12-month Low	% annual change[a]	Price/earnings ratio[b] 1984	Price/earnings ratio[b] 1983	Dividend yield[b,c] 1984	Dividend yield[b,c] 1983
Air Products	$40	$48⅜	$36⅛	3%	10	13	2.6%	2.2%
American Cyanamid	50	53⅛	42⅛	0	11	16	3.8	3.5
Celanese	81⅛	82	62¾	18	7	23	5.4	5.8
Chemed	28⅝	36⅝	24⅝	−27	11	16	5.6	3.7
Crompton & Knowles	21¼	23¾	19¼	−10	9	12	5.7	4.8
Dow Chemical	27½	34½	25¾	−18	10	26	6.5	5.4
Essex Chemical	20¼	22⅛	15⅜	−4	10	13	4.0	3.8
Ethyl	32	33¼	20	25	11	10	2.7	3.3
First Mississippi	8⅞	13¾	7¼	−26	9	25	2.7	2.0
Freeport-McMoRan	16¾	25¾	13½	−17	13	26	3.6	3.0
H. B. Fuller	14⅝	16¼	11¾	−26	10	13	2.1	1.4
W. R. Grace	39¾	46⅞	36½	−12	10	14	7.0	6.2
Hercules	33⅞	38	27¼	−5	9	14	4.7	4.0
International Flavors	28	29¼	22⅞	3	15	15	4.0	4.0
International Minerals	37¼	49	32⅞	−14	11	14	7.0	6.0
Loctite	34	42¾	30⅝	−18	13	21	2.4	1.4
Lubrizol	21⅜	24½	16¼	−2	13	15	5.4	4.9
Monsanto	44	53⅞	40⅝	−16	8	12	5.2	4.0
Morton Thiokol	27⅝	31½	20	7	12	14	2.3	2.3
Nalco Chemical	26½	33¼	21	−15	14	20	4.5	3.9
National Distillers	26⅛	30	22¾	−5	13	20	8.4	8.0
Olin	30	33½	25⅛	−2	8	13	5.0	4.3
Pennwalt	39	42¼	31½	−4	10	19	5.6	5.4
Petrolite	26¼	32½	24½	−7	13	15	4.3	3.5
PPG Industries	32⅞	38	24¾	−6	8	12	4.4	3.7
Reichhold Chemicals	32½	35⅝	23	−2	9	15	2.5	1.8
Rohm & Haas	63⅞	69¼	48⅛	5	9	12	3.1	2.6
Stauffer Chemical	17½	25¾	15¾	−30	34	def	8.2	5.8
Union Carbide	36¾	65¼	32¾	−41	13	20	9.3	5.4
Witco Chemical	34	39½	27⅝	−4	8	11	4.4	3.7

a From year's end 1983. b As of year end. c Dividend as percentage of stock price.

ous recoveries. Add to this the problem that the value of the dollar is making imports cheaper and more competitive with U.S. products, thereby taking up some of the domestic demand, and one can easily see that foreign trade is giving the chemical industry and its earnings fits.

In addition, there is concern about the industry itself—concern about the costs of regulation and concern about what direction the industry is taking. This latter is manifest in analysts' discussions of the maturity of the industry and its moves to find higher-value-added products. Many analysts, although applauding the moves into specialties or diversification by the industry, are taking a wait-and-see attitude toward the transformation. They point out that the industry is so dominated by large-volume basic chemicals that it will take some time and a lot of investment before the diversification moves will make themselves felt.

The result is that despite good performance in the first half of 1984, the earnings outlook for chemicals since then has just not been that good—and it continues to be lackluster.

Hence, stock prices for the chemical industry have fallen and are continuing to stay down. The 20% drop in C&EN's chemical stock index in 1984 was matched only by an equal fall in the Over-the-Counter Industrials. The most widely quoted of the market indicators, the Dow Jones Industrial Average, fell just 4% between the end of 1983 and the end of 1984. And two of the very broad indicators—the New York Stock Exchange Composite and the Standard & Poor's 500—actually managed almost 1% gains.

Of the 30 stocks surveyed by C&EN, only six—Ethyl, Celanese, Morton Thiokol, Rohm & Haas, Air Products, and International Flavors & Fragrances—managed an increase through 1984. One, American Cyanamid, held even with the end of 1983. The remaining 23 all showed declines of 2 to 41%. At the high end of that range, 41%, was Union Carbide, which probably is a special case because its stock price fell 24% in December in the aftermath of the Bhopal, India, tragedy. Before the Bhopal incident, Carbide's stock price had dropped just 22% from the end of 1983.

The situation at year's end could have been worse for the companies, however, since they were closer to their yearly highs than they were to their lows. The average stock price for the 30 companies at the end of the year was up 22% from the average 12-month low, but down just 15% from the average 12-month high for the group.

Reflecting the lack of earnings confidence in the group, the average price/earnings ratio dropped during the year. At the end of 1983, when the recovery was well under way and earnings expectations for chemicals were rosy, the average price-earnings ratio for the 30 companies was 16. However, as confidence eroded, so did the ratio, until at the end of 1984 it had sunk to just 11. This average would have been even lower but for Stauffer Chemical, which finished the year with a price/earnings ratio of 34 on a dismal earnings performance.

For this year it seems like more of the same. Analysts still see problems continuing for the industry—problems such as pricing, foreign trade, and regulatory costs, the last of even more concern since Bhopal. And they have added a few new ones, chief among them slowing of production brought about by declining demand in the general economy and inventory reduction among downstream customers. Thus, analysts expect nothing great from chemical stocks in 1985. In fact, they seem to be on few recommended lists. □

Engineering resin demand rose sharply last year

U.S. consumption of engineering resins spurted 18% last year over 1983 to a record 1.15 billion lb, according to Frank M. O'Neill, business director for Celanese's engineering resins division. Worldwide, use of these plastics vaulted 14% to 3.05 billion lb, he says. These figures include nylon, polycarbonate, polyphenylene oxide, polyacetal, polytetramethylene terephthalate, polysulfone, and polyphenylene sulfide, and do not include fluoropolymers or acrylonitrile-butadiene-styrene (ABS).

Celanese's own sales of nylon, polyacetal, and polytetramethylene terephthalate also increased 18%, O'Neill says, both in the U.S. and through its West German and Japanese affiliates. Those affiliates are Ticona Polymerwerke, a joint venture with West Germany's Hoechst, and Polyplastics Co., a joint venture with Japan's Daicel.

Celanese has begun a $35 million debottlenecking of its polyacetal facility at Bishop, Tex., expanding capacity to 155 million lb per year from 120 million lb, slated for completion in 1985. The company also will build new engineering resin plants in Brazil and Mexico. In December, Celanese started up a 9 million lb-per-year compounding plant at Florence, Ky. Thomas C. Bohrer, vice president and general manager of Celanese's engineering resins divison, has estimated that compounds for specialized cost-performance niches will grow to 30% of all engineering plastics by 1991.

O'Neill cites high auto sales in 1984 coupled with continued increase in weight of plastics per car as one reason for the strong showing of engineering resins in the U.S. Another factor was increased housing starts, which led to greater sales to plumbing, appliance, and hardware industries. A third contributor was electrical and electronics sales, spearheaded by personal and small business computers. Overall, routine use of computer-aided design and manufacture catalyzed continued replacement of metals by plastics, O'Neill says.

These same economic considerations sparked growth in other parts of the world, he says, where concerns to save energy were an additional factor. Continued economic strength in Japan, recovery in Western Europe, and increased exports to developing countries brought a rise in exports from the U.S. About 20% of U.S. engineering resin production is exported now, up from 16% in 1979.

For the future, O'Neill predicts that 1985 again will be a strong growth year in the U.S., with sales of engineering resins advancing 7 to 8% to 1.23 billion lb. Saturation of end-use markets will slow growth to 3 to 4% in 1986, he adds, reaching only 1.28 billion lb. A renewed surge of growth after that likely will top 1.7 billion lb in 1989, O'Neill concludes. □

U.S. engineering resin use hit record high in 1984 . . .

Millions of lb	U.S.	Rest of world	Total
Nylon	403	841	1244
Polycarbonate	300	345	645
Polyphenylene oxide	175	183	358
Polyacetal	128	374	502
Polytetramethylene terephthalate	120	142	262
Polysulfone	13	5	18
Polyphenylene sulfide	10	10	20
TOTAL	1149	1900	3048

. . . led by these markets . . .

	% of sales	% annual change
Transportation	28%	10%
Construction[a]	13	6
Electrical & electronic[b]	25	15
Industrial machinery	15	3
Other[c]	19	8

. . . and is poised for strong growth

Millions of lb	1984	1989	% annual change
U.S.	1149	1703	8–8.5%
Japan	616	926	8–9
Western Europe	1028	1343	5–6
Other	255	330	5–5.5
TOTAL	3048	4302	7–7.5%

a Housing, plumbing and hardware, appliances, glazing and lighting. b Business machines, industrial, communication. c Recreation, consumer goods, packaging. Source: Celanese

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NEWS

Federal policy makers, industry chiefs debate biotechnology regulation
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News of the Week

■ **Proposed major revisions to EPA's guidelines for cleanup of toxic waste sites would speed up action and reduce paperwork.** **Page 6**

■ **Workforce reductions at Du Pont and Hoffman-La Roche affect thousands of employees.** **Page 7**

■ **Researchers document relationship between blood pressure and blood lead levels.** **Page 7**

■ **FDA approves oral drug that can help prevent recurrent outbreaks of genital herpes.** **Page 7**

■ **More toxic gas leaks at Institute, W. Va., reported to EPA by Union Carbide.** **Page 8**

Cover: Preplanting application of anhydrous ammonia to midwestern cornfield. Photo courtesy of Farmland Industries Inc.

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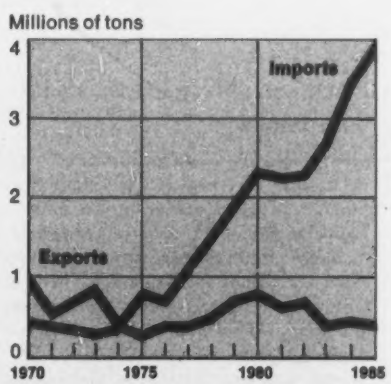


Cover Story

U.S. producers of petrochemicals based on natural gas face slowdown in production owing to negative trade balance. **Page 10**

Production Slows for Natural Gas-Based Petrochemicals

Slowdown, caused by negative trade balance, coupled with steady demand for products could increase dependence on ammonia, methanol imports

Bruce F. Greek, C&EN Houston

A long-expected shift to a negative trade balance has occurred for chemicals made in the U.S. mainly from natural gas. That shift is causing a slowdown in production of ammonia, urea, and methanol, even though demand for these products is remaining steady or even increasing slightly.

And with the prospects good that U.S. production capacity for gas-based chemicals will decline, the longer-term result could be a greater dependence on foreign sources of ammonia and methanol. Currently, demand—exports and U.S. consumption—for ammonia, methanol, and their derivatives is about equal to supply—production plus imports. However, if U.S. consumption were to rise or imports decline, exports likely would have to be cut to provide supplies to meet demand, further contributing to a negative trade balance.

Economics now seem to be less favorable for production of these chemicals in the U.S. than in some foreign countries. Consequently, more U.S. plants could be shut down, and those already down would become less likely, because of deterioration, to restart. Eventually, capacity to make ammonia and methanol and their derivatives could become inadequate if demand were to surge because of weather or increased planting following a crop failure. Higher prices could increase imports if they are available, but also could compound the shortage problem.

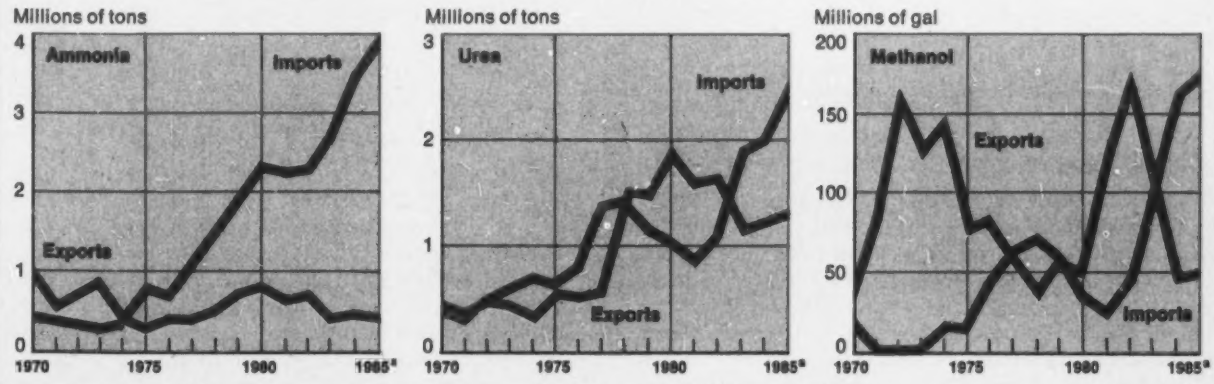
Key Chemicals

The decline in ammonia, urea, and methanol exports is being caused by two conditions. One is that the new plants built in countries having low-cost natural gas also supply product to markets once supplied by U.S. exports. Because of the lower-cost feedstock at the foreign plants, U.S. exports no longer are price competitive. The other involves the exports to the U.S., which often sell at prices below U.S. producers' costs. Such sales cut into U.S. producers' sales so much that operating a plant no longer is profitable. Thus, capacity is reduced, making product for export from the U.S. less available.

This contributes to a rise in chemical imports. The strength of the dollar adds incentive for export to the U.S. Longer term, even if a weakening of the dollar occurs, the cost advantage now enjoyed by foreign producers won't go away and most likely will increase. This means that even more U.S. ammonia and methanol capacity will be shut down.

For details of the near-term outlook for ammonia, urea, methanol, and formaldehyde, see the following pages.

U.S. trade imbalance grows for gas-based petrochemicals



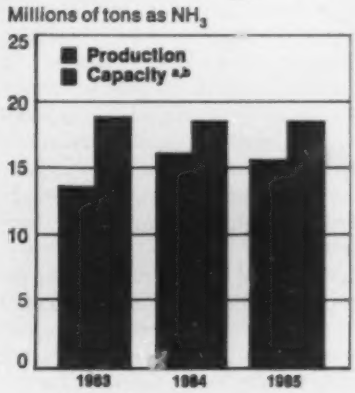
Note: Trade in formaldehyde is negligible because of high transportation costs for solution. ª 1984 and 1985 are estimates.
Sources: Department of Commerce, C&EN estimates

NH_3

Ammonia

- ***Demand uncertain***
- ***Capacity holding***
- ***Prices steady***

PRODUCTION/CAPACITY



a First quarter. b Some capacity shut down.

MAJOR PRODUCERS

CF Industries, Columbia Nitrogen, Farmland, Union Oil, Williams Cos. (Agrico)

HOW MADE

Catalytic reaction of nitrogen from air and hydrogen from natural gas

MAJOR DERIVATIVES (U.S.)

Ammonium nitrate 20%, urea 20%, ammonium phosphates 15%

MAJOR END USES (U.S.)

Fertilizers 80%, fibers and plastics 10%, explosives 5%

FOREIGN TRADE

Exports—declining to about 400,000 tons for 1985, imports—rising to nearly 4 million tons for 1985

PRICES

List prices about $150 per ton on Gulf Coast

Ammonia producers can expect this year to be much like 1984, with little change in production or consumption. At most, demand may rise slightly and production decline a bit.

Currently, demand for ammonia is holding steady, neither high nor low by recent standards, as the planting season gets under way in the warmer sections of the U.S. Most ammonia plants in this country are operating now, ammonia inventories are believed to be about normal, and prices are at about the level they were a year ago. Whether these circumstances will continue throughout 1985 will strongly influence industry profits.

Consumption of ammonia as a fertilizer or in making fertilizers used on U.S. fields probably will be slightly below or equal to that of 1984, depending on money and weather conditions. Feeds and industrial uses could be down perhaps 2 to 5% from their 1984 patterns.

Chemical nitrogen includes both fertilizer and nonfertilizer nitrogen. (Examples of nonfertilizer-nitrogen-containing end products are nylon and melamine.) Total chemical nitrogen consumption during 1985 might be up by a small amount—1 to 2%. That gain would result from higher exports of nitrogen fertilizers, especially diammonium phosphate.

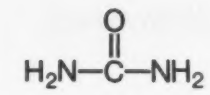
However, an increase in consumption will not necessarily increase ammonia production in the U.S.; output most likely will decrease as much as 5% from last year's 16 million tons or so. Instead, the increased consumption will be supplied from rapidly rising imports, even as U.S. production of ammonia declines. Ammonia exports are relatively small compared to imports and are expected to decline in 1985. Thus a larger deficiency in U.S. nitrogen production relative to consumption will result. Other imported chemical nitrogen fertilizer materials will offset exports of such materials and go largely to fertilizer use.

The export-import situation for ammonia alone makes many in the industry uncertain about the outlook for 1985. Other unknowns such as weather, grain prices, grain export demand, and farm financial conditions make many industry sources admit that their forecasts are no more than educated guesses. But a rough consensus developed from a number of these sources is that U.S. ammonia production will drop less than 5% from 1984 to about 15.5 million tons. Most large-sized plants—those with capacities of 1000 tons per day—will operate most of the year with about 30 days downtime for routine maintenance. Smaller plants that survive because of special marketing situations generally will run as much as needed to keep their market and to maintain a reasonable inventory. As a result, the average operating rate for U.S. plants this year will come to about 85% of nameplate capacity.

Ammonia's consumption pattern in 1985 will be similar to that of recent years, with no new uses of any size expected. None of the nonfertilizer uses of ammonia and its derivatives—which account for about 20% of total U.S. demand—are large enough to have a major impact on the total use, even if consumption should change greatly. Industrial uses, such as those in making acrylic and nylon fibers, explosives, and many small chemical intermediates and their end products, could show minor variations in ammonia demand as their production is influenced by such matters as garment imports, reduced mining activity and changes in preferred explosives, and industrial operations.

If these early forecasts prove accurate, ammonia will have almost as good a year as it did in 1984. But in the face of rising imports from countries with low-cost gas feedstocks, ammonia production in the U.S. is facing the unpleasant prospect of a continuing decline in the next several years unless U.S. natural gas prices drop drastically.

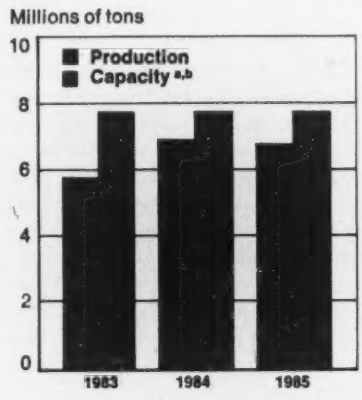
Key Chemicals



Urea

- ***Demand may rise***
- ***Capacity on hold***
- ***Prices under pressure***

PRODUCTION/CAPACITY



a First quarter. b Some capacity shut down.

MAJOR PRODUCERS

CF Industries, Columbia Nitrogen, Farmland, Union Oil, Williams Cos. (Agrico)

HOW MADE

Reaction of ammonia and carbon dioxide under pressure

MAJOR DERIVATIVES (U.S.)

Urea-formaldehyde resins 5%

MAJOR END USES (U.S.)

Fertilizers 80%, animal feeds 10%, adhesives and plastics 5%

FOREIGN TRADE

Exports—may rise slightly to above 1.25 million tons in 1985, imports—rising rapidly to around 2.5 million tons in 1985

PRICES

List prices about $150 per ton on Gulf Coast

The outlook for production of urea in 1985 holds uncertainties similar to those for ammonia. These uncertainties could be extended as well to other high-nitrogen-content fertilizers that often compete with urea and ammonia.

At this time, however, urea production, inventories, and selling conditions are running about normal for this time of the year. Changes could come in all of these factors, caused by changes in demand, as a better idea of the success for fertilizer sales develops this spring along with the outlook for housing, which is the major nonagricultural end use for urea.

Based on early forecasts, urea producers will not have nearly so good a year in 1985 as they did last year. In 1984, production of urea reached an estimated 6.9 million tons, up some 19% from 1983. In 1985, production probably will be down slightly, less than 5%, to the 6.5 million to 6.7 million ton range.

Forecasts for 1985 urea production attempt to take into account U.S. consumption of urea and the net difference between imports and exports. The domestic consumption of urea will depend on many of the usual conditions, starting with weather, actual applied costs relative to similar costs of other fertilizer nitrogen sources, and planted acreage.

Weather, while not so absolute a factor as cost, can heavily influence urea use. If the spring weather provides generally dry and relatively easy-to-work fields, anhydrous ammonia will be used more heavily than urea. Urea-ammonium nitrate solutions rank in between.

The costs of applied fertilizer nitrogen to farmers and planters rank first, as might be expected, in most decisions of which material to use. Shifts in prices of ammonia and urea at plant sites bring even larger swings in prices that farmers pay. Therefore, substitution could become important, especially as farms get larger and purchases of fertilizer and the cost of its application account for large amounts of money to the individual farmer.

Prices of nitrogen fertilizers are strongly affected by the trade situation. Imports of urea have risen rapidly and may exceed 2.5 million tons in 1985. As is the case with ammonia, imports of urea from countries with large, low-cost supplies of natural gas offer many benefits to the exporting countries. Generally, hard currency is obtained, and the gas is exported in a profitable form in contrast to little or no use as yet in the producing country. Plant operating problems have limited some countries' urea exports to the U.S. in the past, but now perhaps experience has reduced these problems.

Exports of urea from the U.S., especially to the Far East, continue at higher levels than were anticipated some years ago. However, they are well down from the peak of nearly 2 million tons set in 1980, with rough estimates for 1985 at about 1.25 million tons.

This net trade imbalance of about 1.25 million tons of urea in 1985 will keep plant operating rates lower than desirable for good profitability at about 85% of nameplate capacity. Some of the small plants either will continue their current shutdowns or will be shut down after the main fertilizer season is over. This will indeed be true for those that depend on an adjacent ammonia plant for a supply of carbon dioxide.

The feed and industrial markets for urea take about 15% of U.S. consumption. Feed use always faces strong price competition from other sources of nitrogen such as molasses, so probably will not grow much if at all. Industrial uses are dominated by urea-formaldehyde resins used as adhesives for particle board for interior construction, especially for housing—a use that may remain unchanged or decline slightly in 1985.

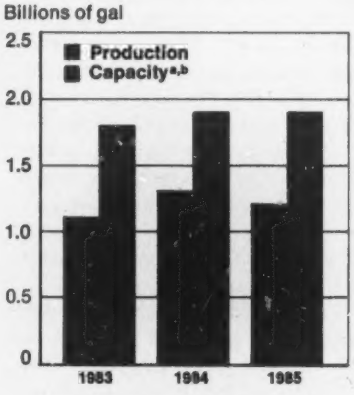
Urea, then, will have a slightly down year with production declining after a good recovery in 1984.

CH_3OH

Methanol

- **Demand soft**
- **Much capacity down**
- **Prices weak**

PRODUCTION/CAPACITY



a First quarter. b About 25% shut down.

MAJOR PRODUCERS

Arco Chemical, Borden, Celanese, Du Pont, Texaco

HOW MADE

Reaction of carbon monoxide and hydrogen made by reforming natural gas (methane) or heavier hydrocarbons; or by coal gasification

MAJOR DERIVATIVES (U.S.)

Formaldehyde 30%, acetic acid 10%, chloromethanes 10%

MAJOR END USES (U.S.)

Polymers used as adhesives, fibers, and plastics 50%

FOREIGN TRADE

Exports—slowing to under 50 million gal in 1985, imports—rising to more than 175 million gal

PRICES

About 40 cents per gal in volume sales on Gulf Coast

With no new uses, including the much talked about fuel uses, to push up demand, methanol production will decline a small amount in 1985. Pressure will remain on prices because of the possibility of more imports. Profitability will remain marginal for operating plants, making methanol production a business segment of the chemical industry from which an exit seems attractive.

Production of methanol in 1985 will total about 1.2 billion gal, down 8% from last year. This decline will result from higher imports to help satisfy U.S. demand. Depending on future pricing, the slow decline in methanol production could be setting the pattern for the future.

Capacity to make methanol exceeds estimated production in 1985 by more than half. This will cause the operating rate to be less than 65% for all of this year, assuming that all capacity is operable and that demand will be large enough to allow production to reach 1.2 billion gal.

Amazingly, the industry currently has more than one third of its capacity shuttered. How much of this shut-down capacity will run again remains a big question. If past experience is any indicator, quite a bit of it will never run again. The time between shutdown of capacity and actual scrapping can be many years.

The two thirds of total U.S. methanol capacity still operating will be running almost full out this year. Such a situation leaves little margin for any kind of maintenance downtime beyond the routine or for any major plant modifications that would help efficiency.

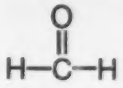
The methanol industry currently is working off some excessive inventories built up during the latter part of 1984. Moreover, imports of methanol are readily available at only slightly higher prices from several countries, such as Canada, Trinidad, and Saudi Arabia, if U.S. production becomes limited for any time as a result of a plant mishap. The use pattern for methanol continues to change slightly with some effect on total consumption. The largest use, formaldehyde, is losing market share to newer uses such as the octane value additive, methyl *tert*-butyl ether (MTBE), and the use of methanol itself as a fuel. MTBE and fuel uses are past their growth spurt and this year will account for about 15% of methanol consumption. Formaldehyde use has dropped from 45% a decade ago to 30% of U.S. consumption.

If methanol prices rise much—a development that even the more hopeful methanol producers don't expect until at least late in the second quarter—or if the price of natural gas to methanol producers declines, then one or more plants could be restarted as a result of better economics.

For now, however, producers of methanol who have to pay upwards of $2.50 per 1000 cu ft of natural gas barely are recovering their cash costs when they sell their methanol for 40 cents a gal, a typical methanol price for large volumes at plants on the Gulf Coast. If they have old gas contracts—which are now quite rare—for much lower prices, then they could be getting some profit on methanol sales. If they have captive uses for methanol such as making it into formaldehyde and then using the formaldehyde for some higher-value end product, their overall profitability could be better.

The real key to any restart of shutdown methanol capacity now remains the cost of natural gas. Price of methanol ranks next because if it should rise significantly, then more imports would arrive promptly on the U.S. market and quickly put pressure on the higher prices. World crude oil prices now are declining, putting pressure on natural gas prices wherever heating oil might be substituted for gas. But U.S. natural gas prices are unlikely to decline enough to make production costs low enough for keeping out imports of methanol from countries where gas costs are one tenth to one quarter those in the U.S.

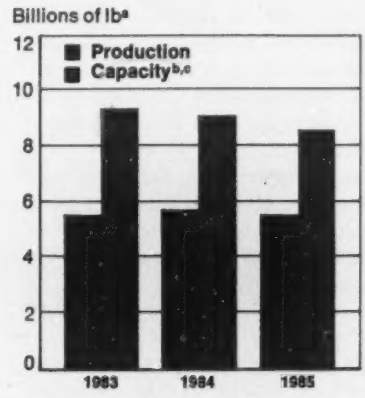
Key Chemicals



Formaldehyde

- ***Demand off a bit***
- ***Capacity holding***
- ***Prices level***

PRODUCTION/CAPACITY



a As a 37% solution. b First quarter. c Various amounts of capacity shut down during the year.

MAJOR PRODUCERS

Borden, Celanese, Du Pont, Georgia-Pacific, Reichhold Chemicals

HOW MADE

Catalytic oxidation of methanol

MAJOR DERIVATIVES (U.S.)

Urea-formaldehyde resins 25%, phenol-formaldehyde resins 20%, polyacetal resins 5%, butanediol 5%

MAJOR END USES (U.S.)

Adhesives 60%, plastics 15%

FOREIGN TRADE

Exports and imports negligible

PRICES

List prices about 9 cents per lb; merchant volume about 30% of production

As might be expected for a product with substantial overcapacity, a shakeout of formaldehyde capacity probably will continue in 1985. More small plants likely will be closed this year as others operate only part time. Many small plants produce formaldehyde for resins containing either urea or phenol as comonomers. These will be hard hit. However, plants making formaldehyde for other resins and chemicals will run most of the year because of stabler markets.

Nevertheless, formaldehyde will continue to have much excess capacity. Some 8.5 billion lb of capacity, calculated on the basis of a 37% formaldehyde solution, are available for operation in 1985, this after elimination of about 10% of total capacity available as this decade began. The current capacity estimate includes some new plants that were added or some expansions that were completed early in the 1980s, partially offsetting plant shutdowns and scrappage.

In contrast to methanol, formaldehyde plants are relatively widespread and include a large number of small plants, some of which produce entirely for captive uses as do many of the larger plants. Because formaldehyde is expensive to ship—which accounts for the existence of very little foreign trade in the material—small plants are built to serve specific areas, especially if they are to make formaldehyde for use in adhesive resins for particle board and plywood. These plants are located close to mills making these wood products, which, in turn, are located near suitable timber lands. The shifting of wood-product production and the changes in demand for these products, as housing and other construction varies, account for much of the variation in formaldehyde capacity and production.

Formaldehyde plants are relatively easy to operate and to start up and shut down. Inventories as a result usually are low. Prices also vary widely because of the segmented nature of production. High transportation costs limit shipment to an area of high temporary demand, causing prices in some locations to be considerably higher than in others.

As a result, variations in formaldehyde production can be frequent, large, and dependent on end-product demand. The end-product demand, particularly for making adhesive resins, likely will be down some in 1985 as a result of lower housing starts and less commercial building. Because these areas of construction are heavily dependent on interest rates for loans, forecasts for housing for 1985 range widely and include numerous qualifications concerning expectations for budget deficits and other factors that affect interest rates.

Formaldehyde production this year likely will be about 5.5 billion lb, as 37% solution, down 3% from 1984. This assumes that nothing significant will happen in 1985 concerning the safety of formaldehyde use. Studies continue on toxicity of formaldehyde. Results are forthcoming soon, and decisions on whether to regulate formaldehyde in various situations could be made in 1985 but probably will have no effect on 1985 production and consumption.

During 1985, no important changes are expected in formaldehyde uses. The resins going into adhesives and plastics will continue to amount to more than 60% of demand, even with some decline in the biggest uses in wood products. Most of the rest of formaldehyde demand is for use as a chemical intermediate in making many different final products. None of these other uses are large or growing fast enough to change the end-use pattern much in the 1980s.

Thus, formaldehyde in 1985 will have a year that might be characterized as average, with production holding about level with last year but down 15% from the 1979 peak of 6.5 billion lb. It may be a long time before this record is surpassed.

Reinforced plastics growth to slacken in 1985

After two very good years of recovery and growth for reinforced plastics, growth of shipments for the industry will slow down considerably this year, according to producers. In fact, the 1985 growth rate will be less than half its 1984 rate.

But even with the slower growth, shipments of reinforced plastics will set a record this year, just as they did in 1984.

A year ago producers were saying that reinforced plastics demand in 1984 would be about 12% above 1983 levels. They turned out to be right on target. Shipments in 1984 increased exactly 12% from the year before to 2.15 billion lb, just a little higher than in the glory years of the late 1970s. The average annual growth rate in the years from 1979 to 1984 was just 1%—good enough to give the industry record shipments, but not very good from a product economics standpoint. The 10-year average annual rate of growth for reinforced plastics between 1974 and 1984 was about 5%, with most of that coming in the first part of the period. In the strong recovery year of 1983, reinforced plastics shipments increased 26% over the year before.

The forecast for this year of a 5.4% increase to 2.27 billion lb will alter those historic growth figures, especially the growth rate for the shorter 1979–84 period. This will increase the five-year growth rate to an annual average of 6% since 1980, which admittedly was a poor year for reinforced plastics shipments, and it will raise the average annual rate for the 10-year period to almost 7%.

These data were reported last week to the annual meeting of the Reinforced Plastics/Composites Institute of the Society of the Plastics Industry in Atlanta. They are part of the yearly survey of producers and others in the industry prepared by Laura Morrison of the New York City-based public relations firm of Morrison/Gottlieb.

According to the survey, the major increase in reinforced plastics demand in 1984 was for land transportation, the largest market for reinforced plastics, which increased 18% from 1983 to 540 million lb. For 1985, however, growth in that area is expected to slow considerably to 5.6%, bringing demand to 570 million lb this year.

Appliances and aircraft uses each increased 16% in 1984, with appliance demand for reinforced plastics rising to 123 million lb and aircraft demand increasing to 29 million lb. For this year, however, growth of appliance use of reinforced plastics is expected to drop dramatically to just 5.7% to 130 million lb. Growth for aircraft applications, long a great hope for reinforced plastics, on the other hand, is expected to continue strong with the growth rate rising to almost 21% and demand in 1985 hitting 35 million lb.

Marine demand, a big-ticket item, strong only in good economic times, increased 12% in 1984 to 309 million lb. For 1985, demand in this area is forecast to grow at a much lower 5% to 325 million lb.

Consumer goods' use of reinforced plastics increased almost 12% in 1984 to 143 million lb. In 1985, this category, in which demand is influenced by many of the consumer spending patterns that also influence appliances, is predicted to increase 4.2% to 149 million lb.

Electrical uses achieved an 11% growth rate in 1984 to 189 million lb. This is expected to increase another 9% during the current year to 205 million lb.

Two seemingly related end markets, construction and anticorrosion applications, came in with almost 8% increases in 1984 with construction rising to 430 million lb and anticorrosion demand increasing to 326 million lb. For 1985, construction uses are expected to pull demand up just 3% to 443 million lb, and anticorrosion demand is forecast to rise 5% to 326 million lb.

Although the entire reinforced plastics industry is growing at a forecast 5% rate this year, Owens-Corning is predicting better increases for the narrower glass fiber-reinforced plastic market with 12% growth this year over 1984, the same rate as in 1984.

Frank W. Como, vice president of the industrial operating division of Owens-Corning Fiberglas Corp., says: "The rapid development of new markets, the strength of existing applications, and a year of continued economic growth will provide an excellent environment for the reinforced plastics industry." Como is particularly bullish on military uses of glass fiber-reinforced plastics, where, he says, "applications have proliferated rapidly." □

Demand for reinforced plastics is forecast to grow about 5% this year

Millions of lb	1985	1984	1983	1982	1981	1980	1975	Annual change 1984–85[a]	1983–84[a]	1980–85[a]	1975–85[a]
Transportation, land	570	540	458	359	445	416	265	5.6%	17.9%	6.5%	8.0%
Construction	443	430	400	312	309	287	175	3.0	7.5	9.1	9.7
Anticorrosion	326	310	288	235	275	252	163	5.2	7.6	5.3	7.2
Marine	325	309	276	230	290	275	285	5.2	12.0	3.4	1.3
Electrical	205	189	170	140	178	162	82	8.5	11.2	4.8	9.6
Consumer goods	149	143	128	84	110	103	64	4.2	11.7	7.7	8.8
Appliance	130	123	106	82	112	104	64	5.7	16.0	4.6	7.3
Aircraft	35	29	25	22	28	25	24	20.7	16.0	7.0	3.8
Other	86	80	72	64	74	70	53	7.5	11.1	4.2	5.0
TOTAL	2269	2163	1923	1528	1821	1894	1175	5.4%	12.0%	6.0%	6.8%

[a] Estimate. Source: SPI Reinforced Plastics/Composites Institute